ON THE EROSION AND THICKNESS OF SHELLS OF THE FRESH-WATER MUSSELS.

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In connection with another investigation, I had opportunity to summarize what is apparently most of the literature dealing with these little discussed and connected phases of the ecology of the Naiades, and now wish to present it in the light of other points this investigation brought out.

Hey (1), compared shells of *U. pictorum* and *U. tumidus* from the Ouse and Foss Rivers in England. The Ouse River is a wide and deep stream with a great deal of mud and receives a variety of drainage material. Hey believed the erosion of the shells in it was due either to the dissolved CO_2 in the water, or the rapidity of the current, for in the Foss River, where conditions were generally opposite ones, they showed little such disfigurement or none. Shrubsole (2) states erosion in shells may be attributed to the low percentage of lime in the water, which he analyzed, and found to be positively correlated with this fact. Beauchamp (3), also, felt that erosion might be due to dissolved carbon dioxide, for he found that shells were considerably eroded in streams flowing through limestone formations; moreover dead shells in water containing an abundance of lime were similarly affected. March (4), however, states that shells from districts highly charged with CO_2 have thin shells, which are not eroded at the beaks, and was inclined to attribute this to the absence of humic acid, "which does not occur where limestone does; or the absence or excess of chalk." Cooper (5) states that badly deformed shells are found in water of excessive saltness, while Baker (6) noted in *Cardium*, a marine pelecypod, that thinness of shell seemed correlated with the saltness of the water. Finally, Rich (7) tells of some shells (*Unio complanatus*) from a soft-water lake in New York which were almost free from lime. Further on in this paper it will be shown that while the waters of Lake Erie contain more lime than those of the Upper Ohio Drainage, shells are comparatively thicker in the latter.

It is at once observed that more of the above writers ascribe erosion of shells to the presence of CO_2 in the water. This is also confirmed in a way from the interpretation of geologic data, which gives evidence of the solvent power of "carbonic acid." Not only is CO_2 being continually liberated in nature in other ways, but there is hardly any doubt but that the interaction of humic acid often present in streams with lime may also produce CO_2. Thus the observation of Shrubsole, whose shells were collected from a drainage containing a diversified material, may plausibly fit in here. Of course the fact must never be excluded that coarser material carried along by the current also plays a part in the erosion of shells, but the consequences of such a factor may be intensified by the chemical reactions which already may have taken place. Most of the eroded shells I have examined come from streams having an abundance of gravel. Again, it is probable that in some cases an abundance of lime in a stream may neutralize the humic acid before the latter can produce any marked effect.

Later on, some evidence will be presented in support of March's contention to the effect that high $CaCO_3$ content of the water somehow inhibits absorption of material, preventing the shell from becoming as thick as it might. This, however, is only a phase of the well-established principle that living cells are able to control the absorption of substances used in their metabolism. Since it is admitted that the lime of shells comes from the water in which they live, there is reason to think there may be some correlation—positive or negative—between the amount of lime present and the thickness of the shells. Several investigators have indicated their probable attack of this problem, but so far there does not seem to be any published results.

Having already secured data on the thickness of the shell and reduced it to a convenient factor, (the thickness just superior to the pallial line directly beneath the umbo, divided by the height), I found a publication of the U. S. Geological Survey (8) which fortunately gave analyses of the water at the same or what seem to be reasonably adjacent points to where my material had been collected. All the localities concerned—collecting, and points where analysis of water was taken, are indicated in the data which appear to correlate for my conclusions in the table.

Table Showing Relation of $CaCO_3$ Content of Water to Thickness of Shell.*

No. Spec. measured.	Genus and Species.	Locality.	m. m. Th.	Parts per million $CaCO_3$.	Stations at which analyses taken with remarks.
8	Fusconaia flava	Allegheny River	.0975	51.4	Parker, Tarentum.
8	Fusconaia flava	Ohio River	.1182	61	Natrona, Pittsburgh.
8	Fusconaia flava	Monongahela River	.142	72	McKeesport, Monongahela.
8	Fuscanaia flava parvula	Presque Isle Bay, Lake Erie	.121	90	Erie, Pa.
15	Amblema costata	Allegheny River	.1495	61	At nearest point, Meadville.
15	Amblema costata	French Creek	.1506	127	
15	Amblema costata	Allegheny River	.1495	51.4	
15	Amblema costata	Ohio River	.1986	61	
4	Amblema costata	Shenango River, Pulaski	.1477	47	Analysis at nearest point, Sharon.
44	Amblema costata	Conoquenessing	.1957	66	
15	Amblema costata eriganensis	Presque Isle Bay, Lake Erie	.1385	90	Erie, Pa.
4	Amblema costata eriganensis	. . . .	.1221	90	Erie, Pa.
13	Pleurobema obliquum	Allegheny River	.1271	61	
13	Pleurobema obliquum	French Creek	.1205	127	
5	Pleurobema obliquum	Allegheny River, Warren, Hickory	.1117	54	Oil City, Warren.
5	Pleurobema obliquum	Allegheny Biver, Kelly	.1061	51	
9	Pleurobema obliquum	Kiskiminitas Drainage	.1142	50	Kiskiminitas and Conemaugh Rivers.
9	Pleurobema obliquum	Kelly, Allegheny River	.1144	51.4	Tarentum.
9	Pleurobema obliquum	Little Mahoning Creek	.1551	26	
9	Pleurobema obliquum	Kelly, Allegheny River	.1144	51.4	Exception.
9	Pleurobema obliquum	Shenango River, Clarksville	.1162	47	Analysis at adjacent points, Sharon and Greenville a greater alkalinity at lower station.

* Where no specific locality is stated, shells from nearest point on map to locality where analysis was made are to be considered.

TABLE—*Continued.*

No. Spec. measured.	Genus and Species.	Locality.	m. m. Th.	Parts per million $CaCO_3$.	Stations at which analyses taken with remarks.
13	P. obliquum pauperculum	Presque Isle Bay, Lake Erie	.1146	90	Erie, Pa.
9	P. obliquum pauperculum	. . . .	.1206	90	Erie, Pa.
15	Elliptio dilatatus	Kiskiminitas Drainage	.1235	50	Kiskiminitas River.
15	Elliptio dilatatus	Kelly, Allegheny River	.1256	51.4	Tarentum.
12	Elliptio dilatatus	French Creek	.1091	61	Exception.
12	Elliptio dilatatus	Kelly, Allegheny River	.1256	51.4	Tarentum.
8	Elliptio dilatatus	Little Mahoning Creek.	.1156	26	Exception.
8	Elliptio dilatatus	Kelly, Allegheny River	.1131	51.4	Tarentum.
4	Elliptio dilatatus	Loyalhanna River, Kiskiminitas Tributary	.135	50	Conemaugh and Kiskiminitas Rivers.
4	Elliptio dilatatus	Cheat River, Monongahela Tributary	.1216	35	Cheat River.
13	Elliptio dilatatus	Allegheny River	.1144	51.4	Tarentum.
13	Elliptio dilatatus	Ohio River	.1181	61	Pittsburgh.
21	Elliptio dilatatus	Shenango River	.0921	47	Average, Sharon, Greenville.
22	Elliptio dilatatus	Slippery Rock Creek	.1092	66	Connoquenessing.
5	Elliptio dilatatus	Greenville, Shenango River	.0952	47	Sharon.
5	Elliptio dilatatus	Shenango River.	.0901	47	Greenville.
21	Elliptio dilatatus sterkii	Presque Isle Bay, Lake Erie	.1104	90	Erie, Pa.
13	Elliptio dilatatus sterkii	. . . .	.1320	90	Erie, Pa.
9	Lasmigona costata	French Creek	.0913	127	French Creek.
9	Lasmigona costata	Allegheny River	.0910	61	Parker.
7	Lasmigona costata	Quemahoning.	.0818	50	Kiskiminitas River, analysis.
7	Lasmigona costata	Kelly, Allegheny River	.0399	51.4	Tarentum.
3	Lasmigona costata	Shenango River, Clarksville, Sharpsville	.0963	47	Nearest points, Sharon and and Greenville, greater alkalinity further down stream.

TABLE—*Continued.*

No. Spec. measured.	Genus and Species.	Locality.	m. m. Th.	Parts per million $CaCO_3$.	Stations at which analyses taken with remarks.
3	Lasmigona costata	Shenango River, Harbor Bridge.	.1058	47	
7	Lasmigona costata	Presque Isle Bay, Lake Erie	.0853	90	Erie, Pa.
5	Anodonta grandis	Shenango River.	.0471	47	At nearest points, Anal., Greenville, Sharon.
5	Anodonta grandis	Wolfe Creek, Connoquenessing	.0630	66	Connoquenessing.
5	Anodonta grandis	Presque Isle Bay, Lake Erie	.1039	90	Erie, Pa.
6	Anodontoides ferussacianus	Linesville, Shenango River	.0518	47	Greenville.
6	Anodontoides farussacianus	Greenville, Sharpsville, Shenango River	.0517	47	Sharon.
6	Anodontoides ferussacianus	Presque Isle Bay, Lake Erie	.0550	90	Erie, Pa.
3	Paraptera fragilis	Edgeworth, Ohio River	.0531	61	Pittsburgh.
3	Paraptera fragilis	Beaver, Ohio River	.0500	51	Beaver Falls.
3	Paraptera fragilis	Presque Isle Bay, Lake Erie	.0455	127	Erie, Pa.
4	Proptera alata	Charleroi, Monongahela River	.0825	49	Monongahela.
4	Proptera alata	Neville Island, Ohio River	.1073	61	Pittsburgh.
8	Proptera alata	Allegheny River	.0991	51.4	Tarentum, Analysis.
8	Proptera alata	Ohio River	.1038	61	Pittsburgh.
8	Proptera alata	Presque Isle Bay, Lake Erie	.0848	90	Erie, Pa.
14	Eurynia recta.	French Creek	.1592	61	French Creek.
14	Eurynia recta.	Allegheny River	.1507	59	Parker.
17	Eurynia recta.	Allegheny River	.1621	51.4	Tarentum.
17	Eurynia recta.	Ohio River	.1675	61	Pittsburgh.
14	Eurynia recta.	Presque Isle Bay, Lake Erie	.1239	90	Erie, Pa.
12	Lampsilis luteola	French Creek	.1223	61	Exception, French Creek.
12	Lampsilis luteola	Allegheny River	.1508	61	Parker.
8	Lampsilis luteola	Greenville, Sharpsville, Shenango River	.1275	47	Average, Sharon, Greenville.

TABLE—*Concluded.*

No. Spec. measured.	Genus and Species.	Locality.	m. m. Th.	Parts per millions $CaCO_3$.	Stations at which analyses taken with remarks.
8	Lampsilis luteola	Slippery Rock Creek.	.1185	66	Connoquenessing Creek.
8	Lampsilis luteola	Allegheny River	.1271	51.4	Natrona.
8	Lampsilis luteola	Monongahela River	.163	72	Monongahela.
8	Lampsilis luteola	Ohio River	.163	61	Pittsburgh.
6	Lampsilis luteola	Little Mahoning Creek	.1291	15	Little Mahoning Creek.
6	Lampsilis luteola	Monongahela River	.1606	49	Pittsburgh.
8	Lampsilis luteola rosacea	Presque Isle Bay, Lake Erie	.1171	90	Erie, Pa.
12	Lampsilis luteola rosacea		.1051	70	Erie, Pa.
6	Lampsilis ovata	Mosgrove, Allegheny River	.1049	51.4	Natrona.
6	Lampsilis ovata	Little Mahoning Creek.	.1001	15	Mahoning, Little.
12	Lampsilis ovata	Allegheny River	.1111	51.4	Natrona.
12	Lampsilis ovata	Ohio River	.1151	61	Pittsburgh.
9	Lampsilis ovata	Shenango River.	.1108	47	Average, Sharon, Greenville.
9	Lampsilis ovata	Slippery Rock Creek.	.1016	66	Connoquenessing Creek.
12	Lampsilis ovata canadensis	Presque Isle Bay, Lake Erie	.1038	90	Erie, Pa.
9	Lampsilis ovata canadensis	Presque Isle Bay, Lake Erie	.0909	90	Erie, Pa.

From the table the following conclusion may be drawn, qualified of course by the conditions under which the data is presented:

1. *In all or the majority of cases discussed from the Upper Ohio Drainage, it appears that the thickness of the shell is positively correlated with the percentage of lime in the water.*

2. *In all the cases of the species from Lake Erie, it appears that the thickness of the shell is negatively correlated with the percentage of* $CaCO_3$ *in the water.*

Why the shells of Lake Erie do not follow the type of correlation obtained for those from the Upper Ohio (should this appear perfectly substantiated), must be largely speculative at present, but the following facts are offered in the light of affecting the ultimate explanation. Walker, (9), has already indicated the general differences between the shells of L. Erie and their parent forms of the Upper Ohio. L. Erie shells are comparatively little eroded, shorter, greater relative degree of inflation, and in some species other characteristics indicating a depauperate type of growth. Certain characteristics of this type are so marked that it has been considered justifiable to assign certain L. Erie shells the rank of varieties (10). Possibly we may recognize the less relative thickness of L. Erie shells as a physiological variation keeping touch with the morphological ones. Dr. Walker in correspondence suggests that these differences as above described may be due to different physical conditions present in L. Erie such as the freedom from disturbance, lower temperature and greater alkalinity of the water. Baker recorded *Cardium* thinnest where the water had the greater saltiness. Comparative and representative analyses of L. Erie and Upper Ohio water show that the former has twice as great alkalinity, and in addition to the greater amount of $CaCO_3$ as already pointed out, a greater proportion of sodium and potassium sulfates, and a large quantity of magnesium carbonate and sulfate which are not reported from the Upper Ohio Drainage. These latter elements occur in sea water to a higher degree than is usually ever reported for fresh water, and their presence may account in the light of the observations I have given, for the effect brackish water seems to have in malforming and depauperating shells, although of course in this particular case the excess of $CaCO_3$ itself, may inhibit extended absorption of itself, or this be prevented by the presence of other compounds. In conclusion, I wish to express my obligation to Dr. A. E. Ortmann, on whose material at the Carnegie Museum these observations were made.

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A NEW ALASKAN CHITON.

BY WILLIAM HEALEY DALL.

Schizoplax multicolor n. sp.

Chiton depressed, broad, wider behind than in front, maroon varied with white streaks, with a rather wide girdle, the surface of which is covered with soft bristles like those of *Mopalia muscosa*, among which are sparsely scattered, irregularly disposed, longer translucent spicules; surface of the valves minutely uniformly reticulate under the lens, appearing smooth to the unaided eye; the mesial suture evident, the fifth valve widest, the